Fabrication Of Shape Specific Biodegradable Porous Polymeric Scaffolds With Controlled Interconnectivity By Solid Free-Form Microprinting

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Introduction

Rapid prototyping (RP) has been used for fabrication of ceramic scaffolds with well defined and reproducible architecture.[1] Scaffolds with well defined porosity have also been fabricated with non-degradable polymers.[2] The objective of this research was to develop a process for fabrication of porous biodegradable and shape-specific polymeric scaffolds for a variety of tissue engineering applications.

Methods

Computer aided design (CAD) using the Solidworks modeling software was implemented to create several different models of the cubic orthoganol geometry. Struts 600 μm in size were designed intersecting at 90° angle to create a matrix of connected cubic pores. The distance between the struts were varied to make three different pore sizes: 300, 600, and 900 μm. Each of the six square faces of a pore were connected to the adjacent pores by a window the same size as the square face and a 600 μm length. A Monte Carlo simulation method was used to vary the degree of interconnectivity between the pores.[3] A number was assigned to each face of the pores in the scaffold. A random number generator was used to select a number corresponding to a face of a pore and the selected face was closed. Different degrees of interconnectivity corresponding to 10%, 20%, and 30% of closed faces of the pores were designed. A .STL file was generated in Solidworks and used to create the machine code necessary to build the scaffolds on a 3D rapid prototyping machine. The PatternMaster rapid prototyping machine (Solidscape, Merrimack, NH) was used to microprint the 3D design with polystyrene (PS; green) and wax (W; orange). PS and W were used to print the solid and pore spaces, respectively. The PS phase of the printed cube was dissolved in acetone and a biodegradable poly(propylene fumarate) (PPF) polymerizing macromer was injected into the wax mold under a vacuum of 100 mmHg. The PPF polymerizing mixture in the wax mold was allowed to crosslink at 40° C for 1 h. Next, the wax was melted leaving the cubical orthagonal degradable PPF scaffold. Synthesis of the PPF polymerizing mixture is described.[4]

Results

A photograph of the CAD design corresponding to the pore size of 300 μm and interconnectivity of 90% (10% of the faces of the pores closed) is shown in Figure 1.

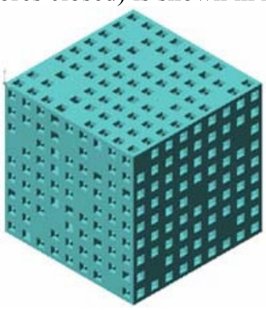

Figure 1

The CAD design in Figure 1 was fabricated by the PatternMaster rapid prototyping machine, as shown in Figure 2.

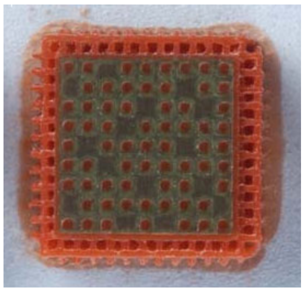

Figure 2

Figure 3 shows a picture of the degradable shape specific scaffold with well defined microarchitecture and interconnectivity after the PPF macromer was injected and crosslinked in the space left by the PS phase and after removal of the wax.

Figure 3

Conclusions

Shape specific biodegradable polymeric scaffolds with well defined and reproducible micro-architecture and controlled interconnectivity was fabricated by microprinting RP technology. This process can be used to fabricate biodegradable polymeric scaffolds with well defined microarhitecture from CT scans for a variety of tissue engineering applications.

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